AD-A054 122 . LETTERMAN ARMY INST OF RESEARCH SAN FRANCISCO CALIF F/G 20/5
RETINAL ALTERATIONS PRODUCED BY LOW LEVEL GALLIUM ARSENIDE LASE--ETC(U) .
FEB 77 E S BEATRICE, D J LUND, D M TALSMA

UNCLASSIFIED LAIR-38 NL

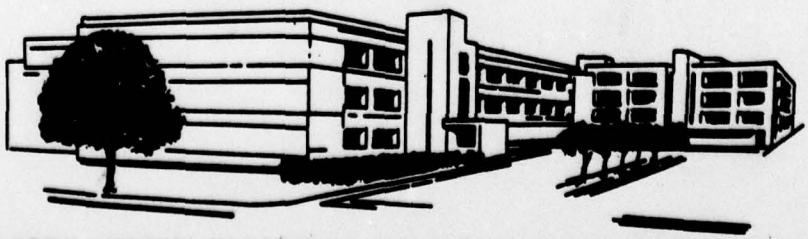
| OF |
ADA
054122

END
DATE
FILMED
6-78
DDC

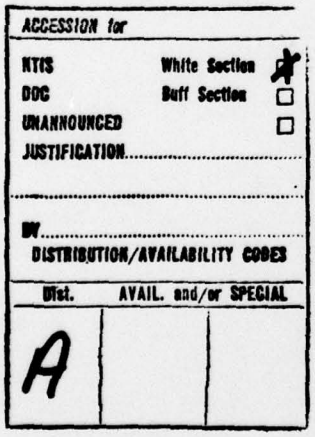
12

LAIR REPORT NO. 38

RETINAL ALTERATIONS PRODUCED BY LOW LEVEL GALLIUM ARSENIDE LASER EXPOSURE



LETTERMAN ARMY INSTITUTE OF RESEARCH PRESIDIO OF SAN FRANCISCO CALIFORNIA 94129



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

(6) 4. TITLE (and Subtitle)
Retinal Alterations Produced by Low Level Gallium Arsenide Laser Exposure.

5. TYPE OF REPORT & PERIOD COVERED
Interim 1 May - 31 Dec 76

6. PERFORMING ORG. REPORT NUMBER

(10) 7. AUTHOR(s)
Edwin S./Beatrice, MD, LTC, MC
David J./Lund A.B., Marshall Carter, SP7
Daniel M./Talsma SP5

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Division of Non-Ionizing Radiation
Department of Biomedical Stress
LAIR, PSF, CA 94129

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
62772A 3A762772A813 021

11. CONTROLLING OFFICE NAME AND ADDRESS
Letterman Army Institute of Research
Presidio of San Francisco, CA 94129

12. REPORT DATE
(11) February 1977

13. NUMBER OF PAGES
8 (11) 11 pp

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
(9) Interim rept, 1 May - 31 Dec 76

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
(14) LAIR-38

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Eye, Retina, Laser Safety, Gallium Arsenide

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The retinas of rhesus monkeys were subjected to irradiation by a prototype gallium arsenide (GaAs) laser training device. The laser device operated at 1600 Hz (pulse repetition frequency mode) or 132 Hz (pulse code mode) with nominal peak pulse power of 1 watt and 10 watts. Exposure durations ranged from 1.0 sec to 90 sec. The tissue reaction at the exposure site was characterized by the development of a pale gray clouding within 10 seconds of initiation of the exposure. The nature of the retinal change could not be determined by ophthalmoscopic, histologic, or flourescein leakage techniques.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

404 912

ABSTRACT

The retinas of rhesus monkeys were subjected to irradiation by a prototype gallium arsenide (GaAs) laser training device. The laser device operated at 1600 Hz (pulse repetition frequency mode) or 132 Hz (pulse code mode) with nominal peak pulse power of 1 watt and 10 watts. Exposure durations ranged from 1.0 sec to 90 sec. The tissue reaction at the exposure site was characterized by the development of a pale gray clouding within 10 seconds of initiation of the exposure. The nature of the retinal change could not be determined by ophthalmoscopic, histologic, or flourescein leakage techniques.

PREFACE

"In conducting the research described in this report, the investigators adhered to the 'Guide for Laboratory Animal Facilities and Care' as promulgated by the Committee on the Guide for Laboratory Animal Facilities and Care, of the Institute of Laboratory Animal Resources, National Academy of Sciences - National Research Council."

TABLE OF CONTENTS

INTRODUCTION

The gallium arsenide (GaAs) semiconductor laser has become the focus of intense interest by the military training community. Incorporation of this small, efficient, inexpensive laser in direct fire simulators will make it more widely deployed in terms of numbers than all other laser types combined. The civilian community has expressed interest in using the GaAs laser as a communications link for audio-visual entertainment equipment that could place the laser in living rooms throughout the country.

In light of all of this interest, the ocular hazard presented by the GaAs laser is poorly understood. The laser emission, coming from a small linear area, is highly divergent and has low power. These characteristics cause difficulties in determining, either experimentally or analytically, the potential of the device for producing retinal damage. Experimental evaluation has been performed with the laser operating at extremely high repetition rates.[1-3] These data are not directly applicable to the output parameters of the proposed training systems. This paper reports an experimental effort to elucidate the ocular hazard of the gallium arsenide laser.

MATERIALS AND METHODS

The laser source used in this experiment was a prototype gallium arsenide laser training device having two modes of operation. In the pulse repetition frequency (PRF) mode, the output consists of a continuous train of 100 nsec full-width-half-maximum (FWHM) pulses at a repetition rate of 1600 Hz. In the pulse code mode, the interpulse spacing is not constant and the average repetition rate is 132 Hz. The pulse energy and duration are the same in both operating modes. The device has the capability of producing nominal peak pulse powers of 1, 5 and 10 watts.

Rhesus monkeys weighing 2 to 3 kg were used. The animals were anesthetized and the ocular pupils dilated. The laser beam delivery system allowed continuous fundus camera observation of the retinal irradiation site during exposure. Dosimetry was accomplished prior to animal exposure by measuring the power passing through a 7 mm aperture at the animal's eye position.

---

[1]Lund, D. J., et al., Frankford Arsenal Report No. M70-24-1, 1970.

[2]Adams, D. O., et al., Invest Ophthalmol, 13:471, 1974.

[3]Lund, D. J., et al., LAIR Report No. 30, 1976.

In each eye a total of forty-eight exposures were made in a grid pattern for exposure durations from 1 sec to 90 sec.

Evaluation of the retinal sites were made by funduscopic observation, intravenous flourescein angiography using both 10 and 20 percent flourescein concentrations, retinal flat preparation, and/or epon imbedded serial sections for light microscopy (Trypan blue, azure II staining). These analyses were carried out for immediate, 1 hour and 24 hour intervals after laser exposure.

RESULTS

Table I lists the average power (P_{av}), peak power (P peak), and pulse energy (Q) incident upon the cornea for the 1 watt PRF mode, the 10 watt PRF mode, and the 10 watt pulse code mode.

TABLE I

Laser Exposure Data

Laser	1 watt	10 watt	10 watt
Mode	PRF	PRF	Pulse Code
P_{av}	34 μw	262 μw	22 μw
P peak	.18 watt	1.5 watt	1.5 watt
Q	.212 erg/pulse	1.64 erg/pulse	1.64 erg/pulse

These ocular exposures did not produce the type of retinal opacity which is typically seen by funduscopy after laser irradiation of the retina. Exposures in the 30-second PRF sequences were characterized by the development of a pale gray clouding within 10 seconds after initiation of the exposure while the laser continued to irradiate the retinal site. At the end of the 30-second interval, the exposure site measured approximately 350-400 microns and was darkened at the periphery with central diffuse clouding.

For the 10-second exposures, the characteristic retinal change observed was smaller (200-250 microns) but typical of the appearance of the other exposure durations.

The subtle retinal change caused by 5-second exposures was smaller (200 microns) but characteristic of the changes seen in the longer exposure series. The incidence of observed retinal changes at various exposure levels is summarized in Table II.

TABLE II

Summary of Laser Exposure Data

Lasers	Mode	Exposure Duration	Number Exposures	Number Changes
1 watt	PRF	90 sec	2	2
		60 sec	7	6
		30 sec	109	67
		10 sec	25	18
		5 sec	7	5
		1 sec	10	0
1 watt	Pulse Code	30 sec	14	0
10 watt	PRF	30 sec	19	11
10 watt	Pulse Code	30 sec	5	5

The subtle retinal changes are persistent (24 hrs after exposure). However, no flourescein leakage or histological evidence of retinal alteration was confirmed in any of the exposure sites.

The exact nature of the retinal change is unknown at this time. The changes was not due to fundus camera illumination because "sham" exposures to the fundus camera illumination alone was made in twelve exposures for 30 seconds with no observed retinal changes. The absence

of histological change is suggestive of subtle superficial retinal alterations in the ganglion cell or nerve fiber layer. These are difficult to confirm.

The precise site of retinal change has not been confirmed since neither ophthalmoscopic nor funduscopic techniques allow resolution of the depth at which retinal layers may be involved.

Because of the low contrast and relatively small retinal area, the observed changes in the retina could not be characterized by either black and white or monochromatic fundus photography.

DISCUSSION

With the exception of the direct observation of retinal "clouding," none of the techniques (angiography, flat preparation, serial microscopy, and fundus photography) routinely used to determine the site or extent of the change demonstrated any retinal alteration.

If the change in the retina was a result of subtle tissue swelling, the preparation of the tissue for light microscopy produces sufficient artifact to obviate this change. The direct ophthalmoscopic observation of change is real enough to warrant reporting this finding since these other techniques may be gross enough to be ineffective in indicating very small areas of ill-defined retinal alteration.

It is postulated that the change may be due to "bleaching" of retinal photopigments or to swelling of photoreceptor or intraretinal neural layers. The presence of some observed retinal change of unknown significance is relevant to personnel who must view these laser sources as a simple test of gallium arsenide laser operation or to those who may use these devices in a routine testing operation where the near infrared radiation is not directly sensed as a potentially hazardous source.

REFERENCES

1. LUND, D. J., C. T. CARVER, J. O. POWELL, G. C. HOLST, and G. H. BRESNICK. Gallium arsenide laser damage threshold study. Report No. M70-24-1. Philadelphia: Frankford Arsenal, July 1970.

2. ADAMS, D. O., D. J. LUND, and P. D. SHAWALUK. The nature of chorioretinal lesions produced by the gallium arsenide laser. Invest Ophthalmol, 13:471, 1974.

3. LUND, D. J., D. O. ADAMS, and C. CARVER. Ocular hazard of the gallium arsenide laser. Report No. 30. Presidio of San Francisco: Letterman Army Institute of Research, October 1976.